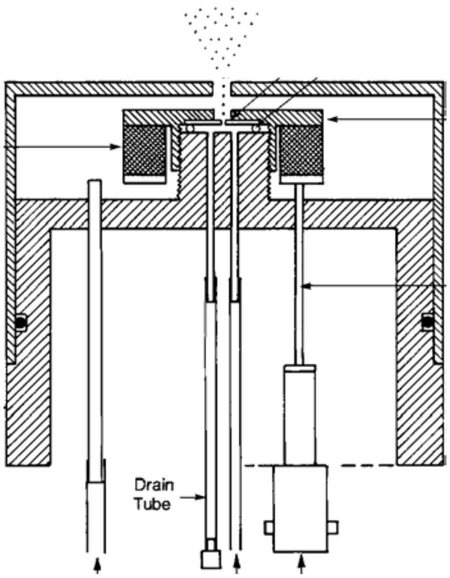
Production of Uniform Particle Standards Using the Vibrating Orifice Particle Generator and Quantification by Optical Particle Sensor

R.A Fletcher, G.A Klouda, and G.J Gillen (837)

CSTL researchers are developing a method to produce accurate and precise particle standards of known composition, size, and number for testing IMS instruments, trace analysis, particle testing and for pharmaceutical research.

Currently there are no standard test materials for calibrating trace explosive detection devices like Ion Mobility Spectrometers (IMSs) for Homeland Defense and there is also a need for test particles to support basic research in particle removal from surfaces using air jets and swipe technologies. The Vibrating Orifice Aerosol Generator (VOAG) can produce monodisperse particles from 0.5 µm to 50 µm made from solution. Each particle contains the same amount of desired test compound that can be controlled by the solute concentration in solution. The precision and accuracy of the VOAG was determined at NIST to be approximately 1% using aerosol sedimentation (velocimetry) – heterodyne elastic light scattering experiments.



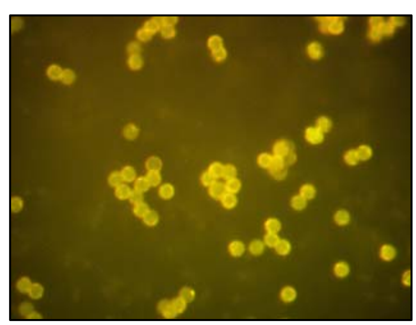
The VOAG allows a wide range of compounds to be made into uniform particles. This is accomplished by dissolving the solute material in the appropriate solvent and delivering the solution by constant pressure through the 20 µm orifice that vibrates at 10 kHz to 100 kHz (driven by a piezoelectric crystal). The number of particles made per second is the same as the driving frequency. The particle stream is dispersed by turbulent clean air flow and then subsequently dried in aerosol form in clean dry air. These dry, uniform particles of known composition are collected on a substrate such as a filter or impacted onto a plate or surface. One complication is that although the number of particles made is known and related directly to the crystal oscillation frequency, the number delivered to the substrate can be greatly diminished due to particle loss during transport from generator to substrate.

The ability to make trace particle standard test materials in a custom fashion for many materials is a valuable addition to our capabilities. Instruments that detect trace explosives and trace drug quantities can be tested and their performance quantified.

An important addition to the VOAG for generation of standard particles would be a capability to accurately quantify the number of particles delivered to the substrate. The detection method must be on-line, non-intrusive and non-destructive. One approach would be to use an in-line optical particle sensor (an individual particle extinction sensor) that would count each particle that passes through the sensor region and that is subsequently collected on the substrate. An additional benefit of this approach is that an extinction sensor can provide particle size and particle uniformity information in a rapid manner.

The operating characteristics and verification of precise particle-making capabilities using a VOAG has been demonstrated. For trace explosive research, we have used the VOAG to produce 8 µm fluorescein particles containing a trace amount of RDX (mass fraction RDX $= 6.7\text{x}10^{-5}$ %) as shown in the figure. The particles appear agglomerated due to the heavy loading on the filter but were single particles as an aerosol. These particle-filter collections were examined by a commercial trace explosives detector based on IMS and gave a positive alarm for RDX.

Fluorescence optical micrograph of fluorescein-RDX particles produced by the VOAG



We are developing an in-situ particle counter that will be used in-line to detect monodisperse particles as they are being deposited on the substrate. Several experts in optical particle sensor design have been contacted and a system has been designed and will be fabricated in FY2005. The detector, which will be based on an extinction or light scattering sensor, will permit not only counting of the deposited particles but also a measure of particle size and uniformity. Also, we hope to extend the capabilities of the VOAG to produce custom biodegradable polymer spheres containing known amounts of pharmaceuticals to support a growing program in microanalysis of biomaterials and drug delivery systems.